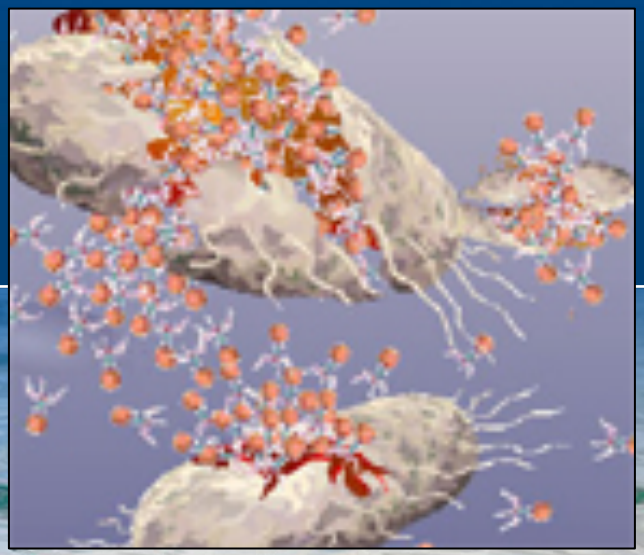
Taking the Waste out of WAS: Sludge Pretreatment for Beneficial Uses

October 30, 2013



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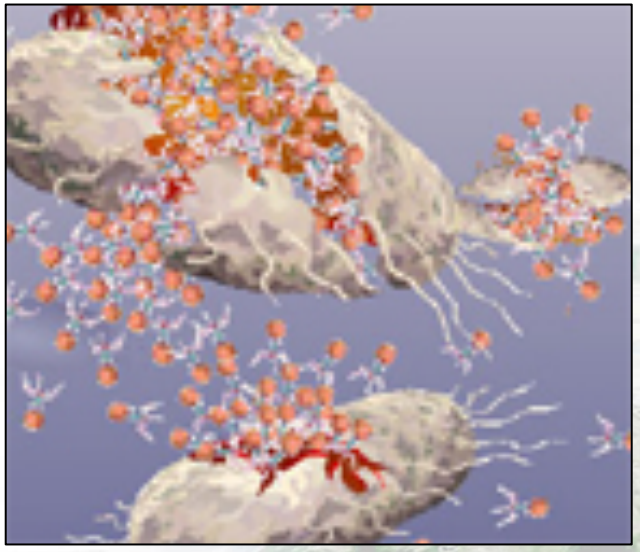
HAZEN AND SAWYER
Environmental Engineers & Scientists

nebra
North East Biosolids & Residuals Association

Agenda

- Why Sludge Pretreatment?
- What is OpenCel?
- Case Study #1: Philadelphia Water Department
- Case Study #2: Henrico County, VA
- Conclusions



Project Partners

Philadelphia Water Department

HRSD

OpenCEL®

HAZEN AND SAWYER
Environmental Engineers & Scientists

Why Sludge Pretreatment?

Just Ask Wally…

But That Isn't The Whole Story

Energy

Reduce (as much as possible)

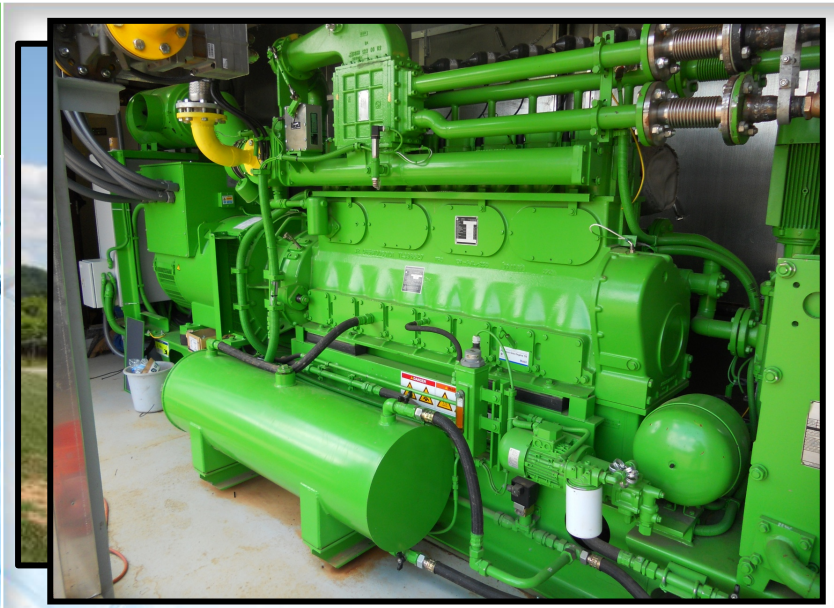
Clean Water

Reuse (as much as possible)

Nutrients

Recover (as much as possible)

Organic Carbon Has Numerous Uses

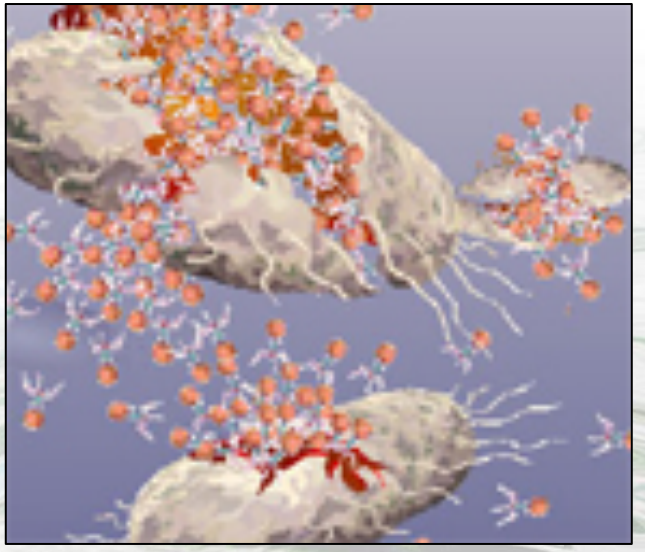


Motivation for Considering WAS Pretreatment

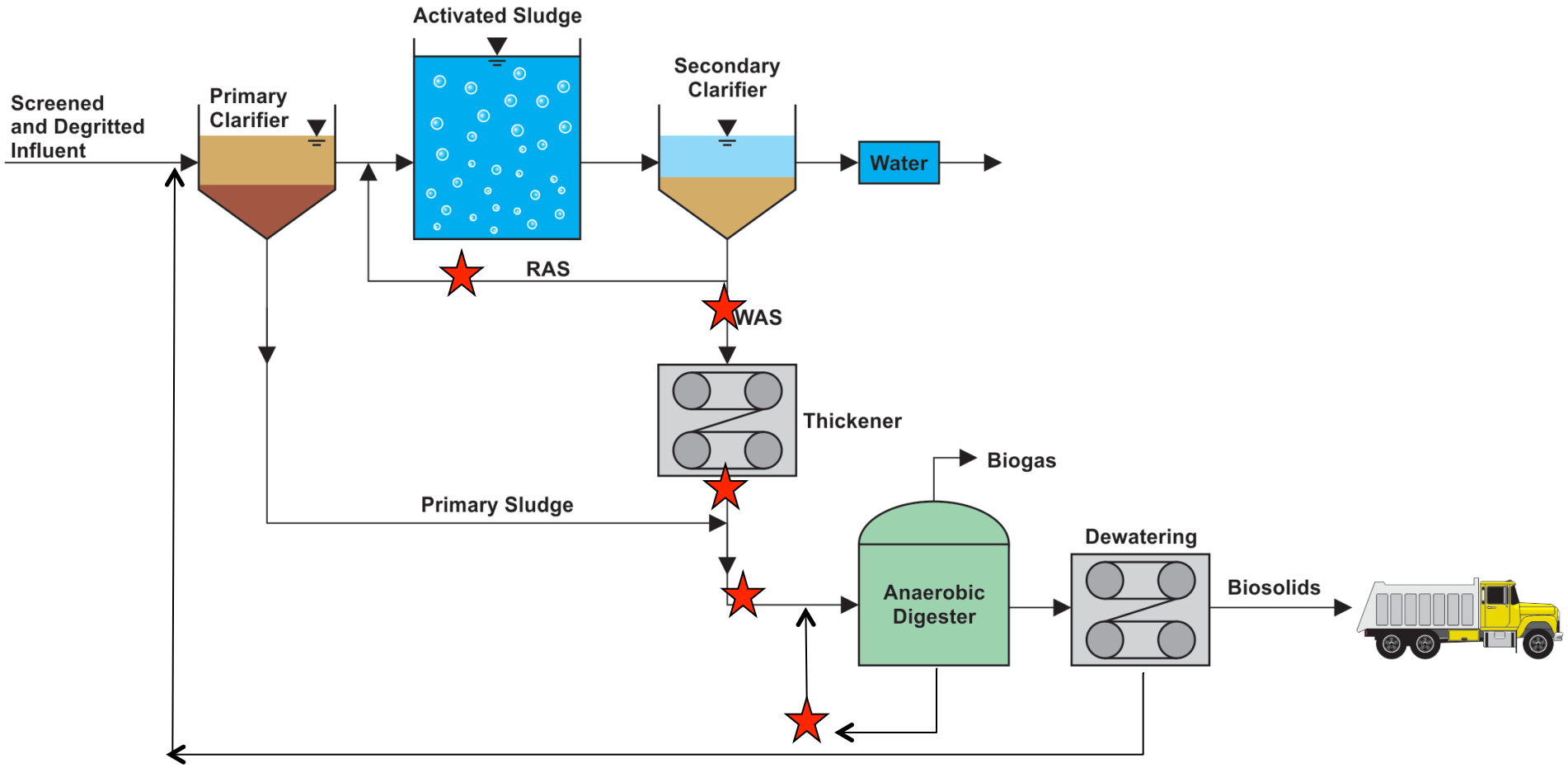
- Lower nitrogen limits → longer sludge ages → decreasing degradability of WAS
- Increasing solids disposal costs
- Increasing stabilization requirements
  - (i.e. Class A Biosolids)
- Minimize solids production / enhance digestion → delay costly expansion (i.e. aerobic or anaerobic digester volume)
- Increase digester gas production
- Supplemental carbon source

Goals of Sludge Pretreatment

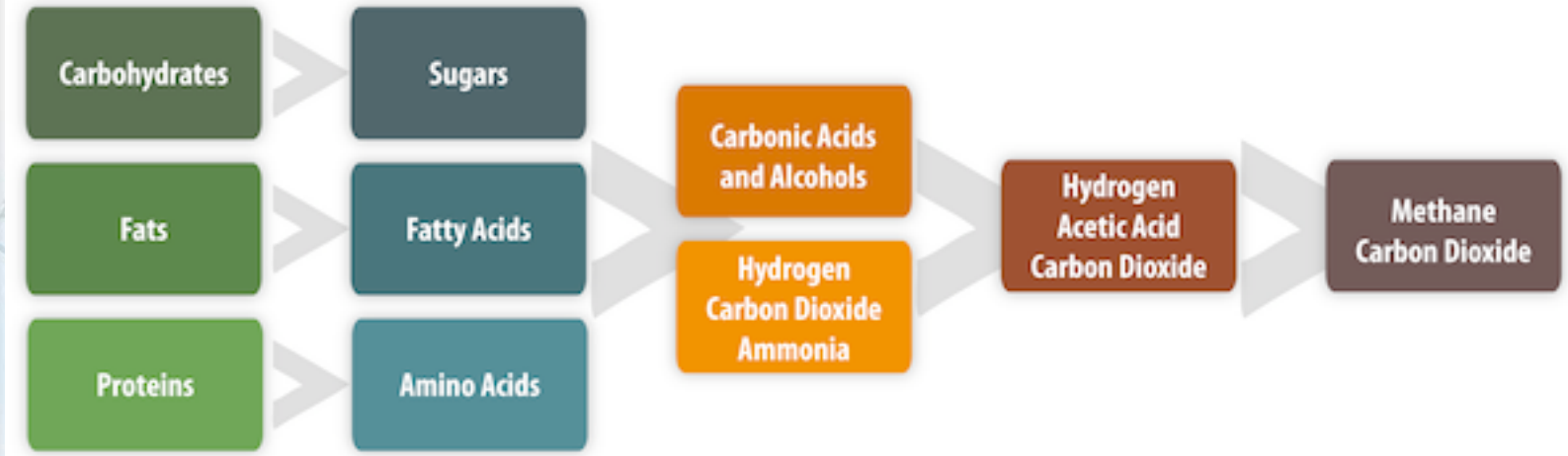
- Floc disintegration
- Cell lysis
- Conversion of particulate organics
- Increase bioavailability
- Increase hydrolysis rate



Where Can Sludge Pretreatment Provide Benefits?



Digester Gas Production Is Directly Related to Volatile Solids Destruction

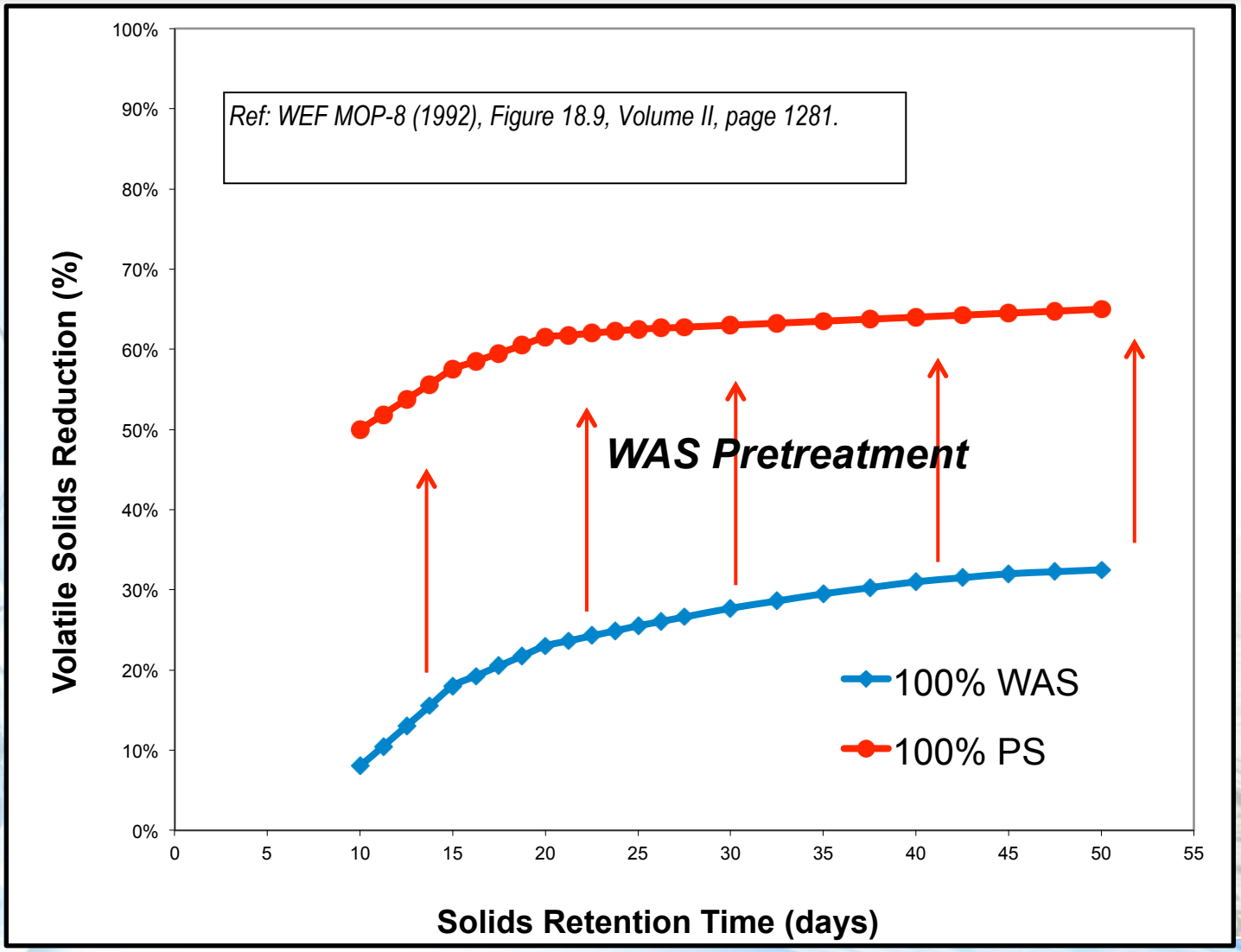


Volatile Solids Reduction (VSR)

Volatile Solids

Soluble Organics Gases

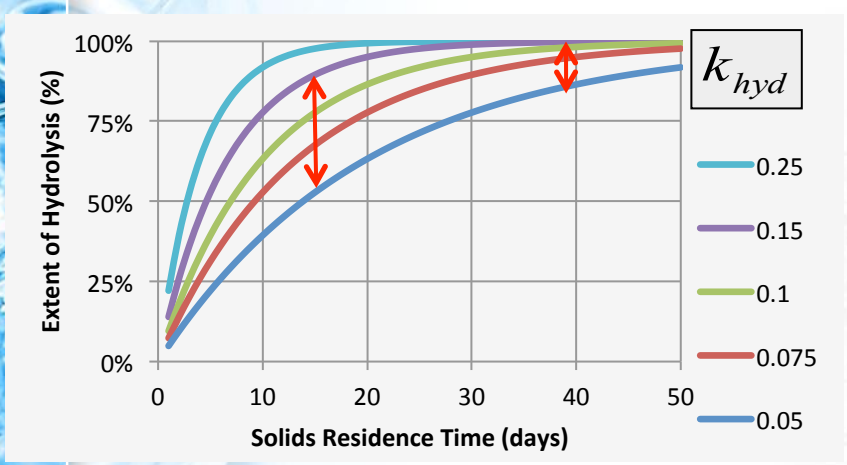
Volatile Solids Reduction is a Function of Digester Solids Residence Time

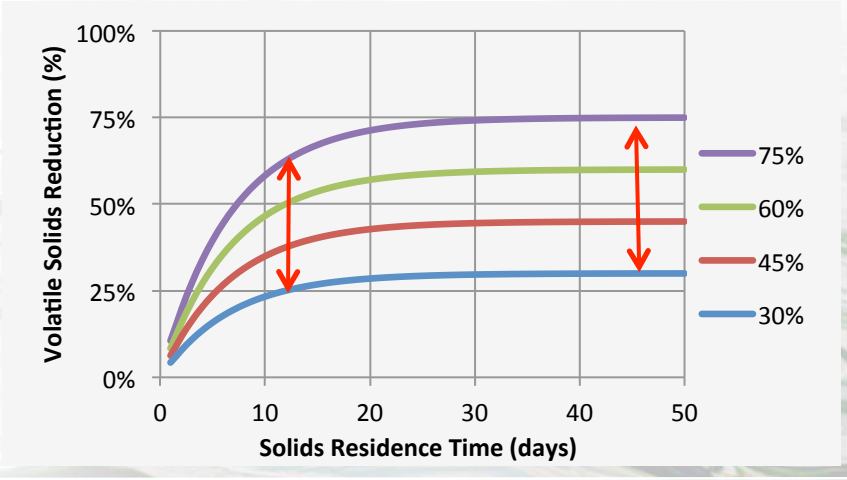


WAS Pretreatment Mechanisms

- Increase rate and/or extent of degradation
  - Low intensity processes → increase degradation rate
  - High intensity processes → increase degradation rate and extent
- How to increase degradation rate?
  - Increase rate limiting step (hydrolysis)
  - Floc/particulate destruction

$$\frac{S_{hyd}}{S_{hyd}^{0}} = 1 - e^{-k_{hyd}t}$$





Sludge Pretreatment Impacts on Digestion

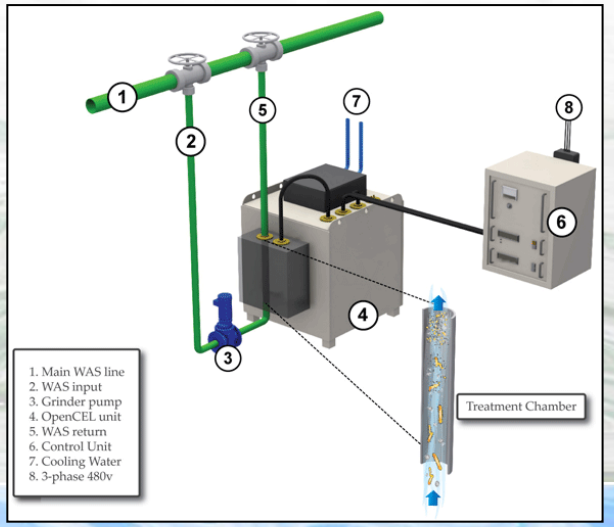
- Why?
  - Increased ultimate degradability or rate of degradation of WAS
  - Increased volatile solids reduction
  - More digester gas produced
  - Increased energy availability

Potential Downstream Impacts

- Increased dewaterability of sludge
- Reduced polymer consumption in dewatering step
- Reduced water mass to downstream processes
  - Reduces energy inputs to thermal process to evaporate water from the sludge

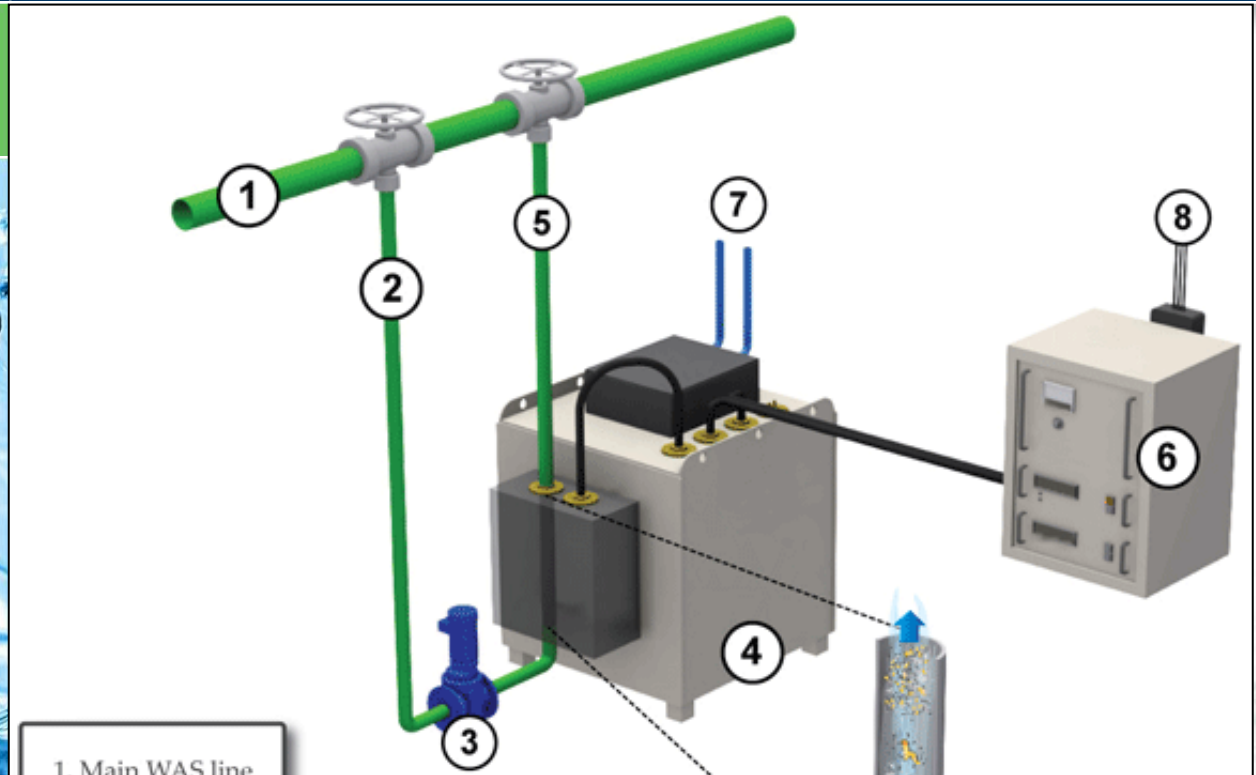
Available Technologies

- Thermal
  - Thermal Hydrolysis
- Mechanical / Physical
  - Ultrasonication
  - High Pressure / Homogenizer
  - Maceration / Mechanical Shearing
- Electric Pulse
- Chemical
  - Ozonation
  - Hydrogen Peroxide
  - Alkali Treatment

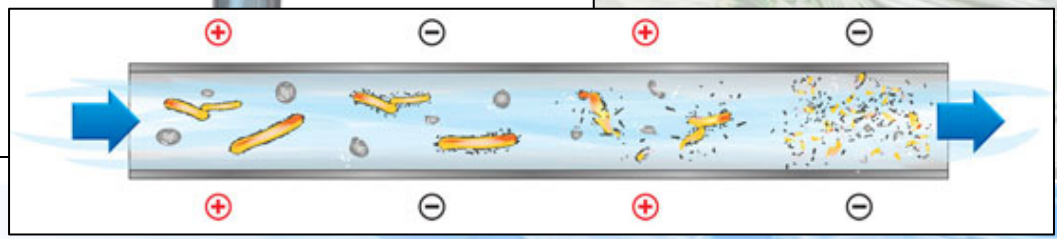


What Is OpenCel?

OpenCel System



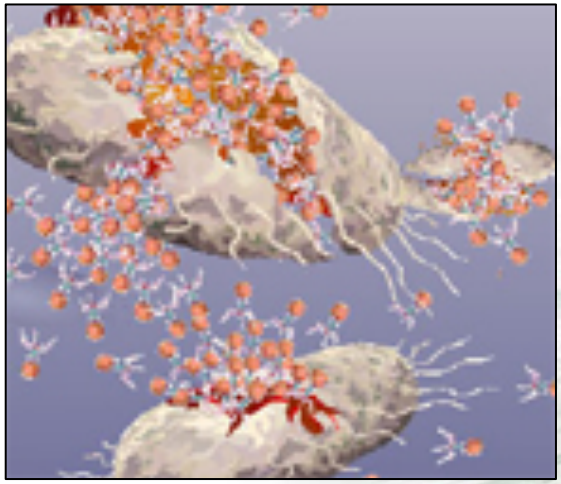
1. Main WAS line
2. WAS input
3. Grinder pump
4. OpenCEL unit
5. WAS return
6. Control Unit
7. Cooling Water
8. 3-phase 480v



Images: OpenCel

OpenCel Theory

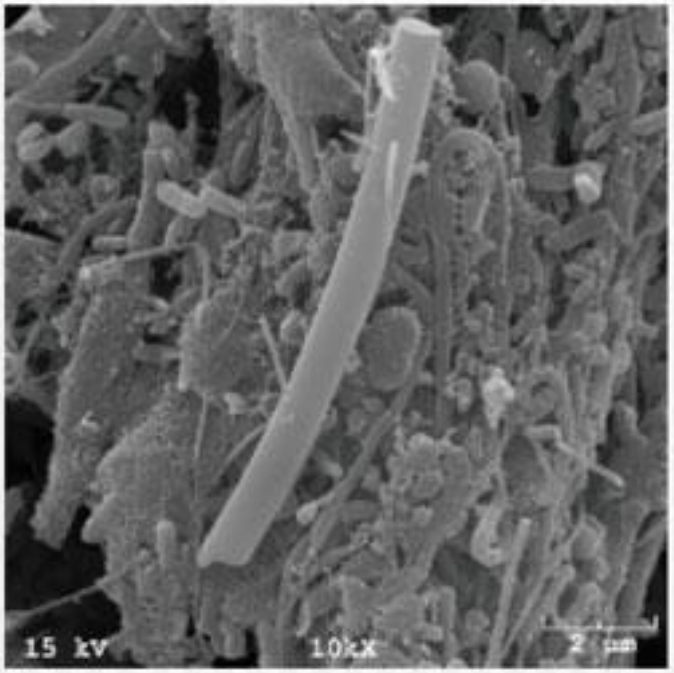
- Focused electrical pulse treatment
  - Cyclic exposure to positive and negative charges weakens the cell wall
  - Eventually the cyclic forces cause cell rupture and release of internal contents



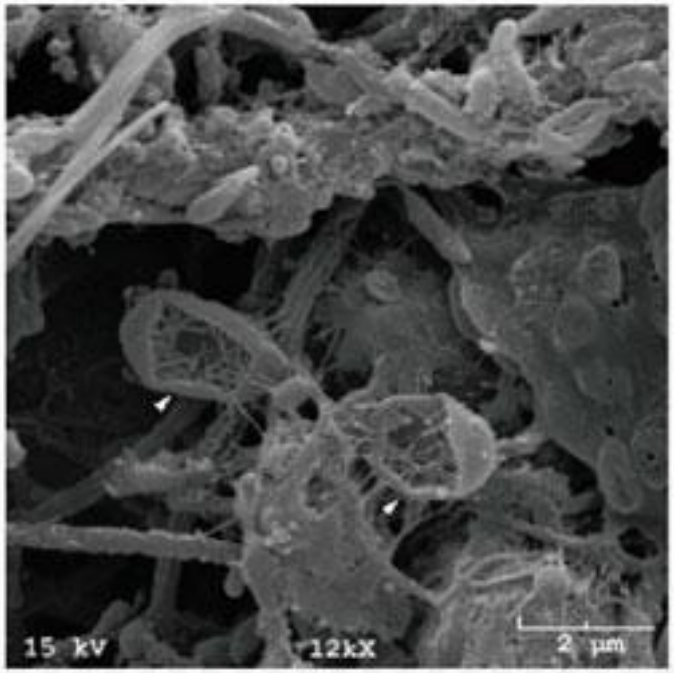
Grinder / Macerator → Focused Electrical Pulse → Floc Disintegration + Cell Lysis

OpenCel Impacts

Before treatment



After treatment



Images: OpenCel

Case Study #1:
Philadelphia Water Department
Southwest WPCP

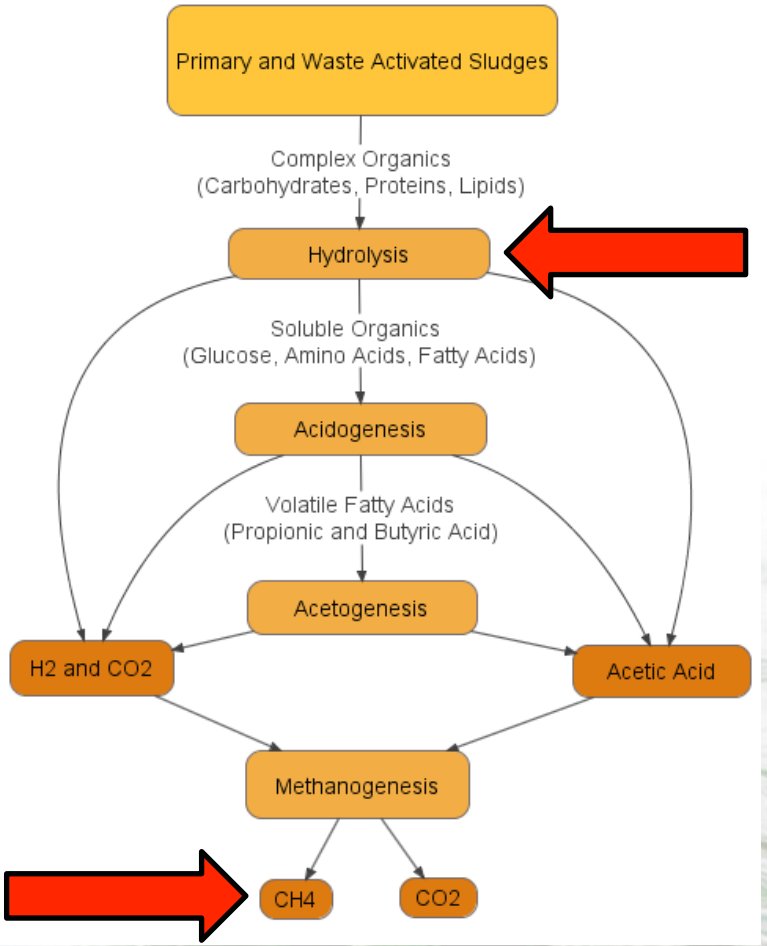
Southwest WPCP

Southwest WPCP Current Operations

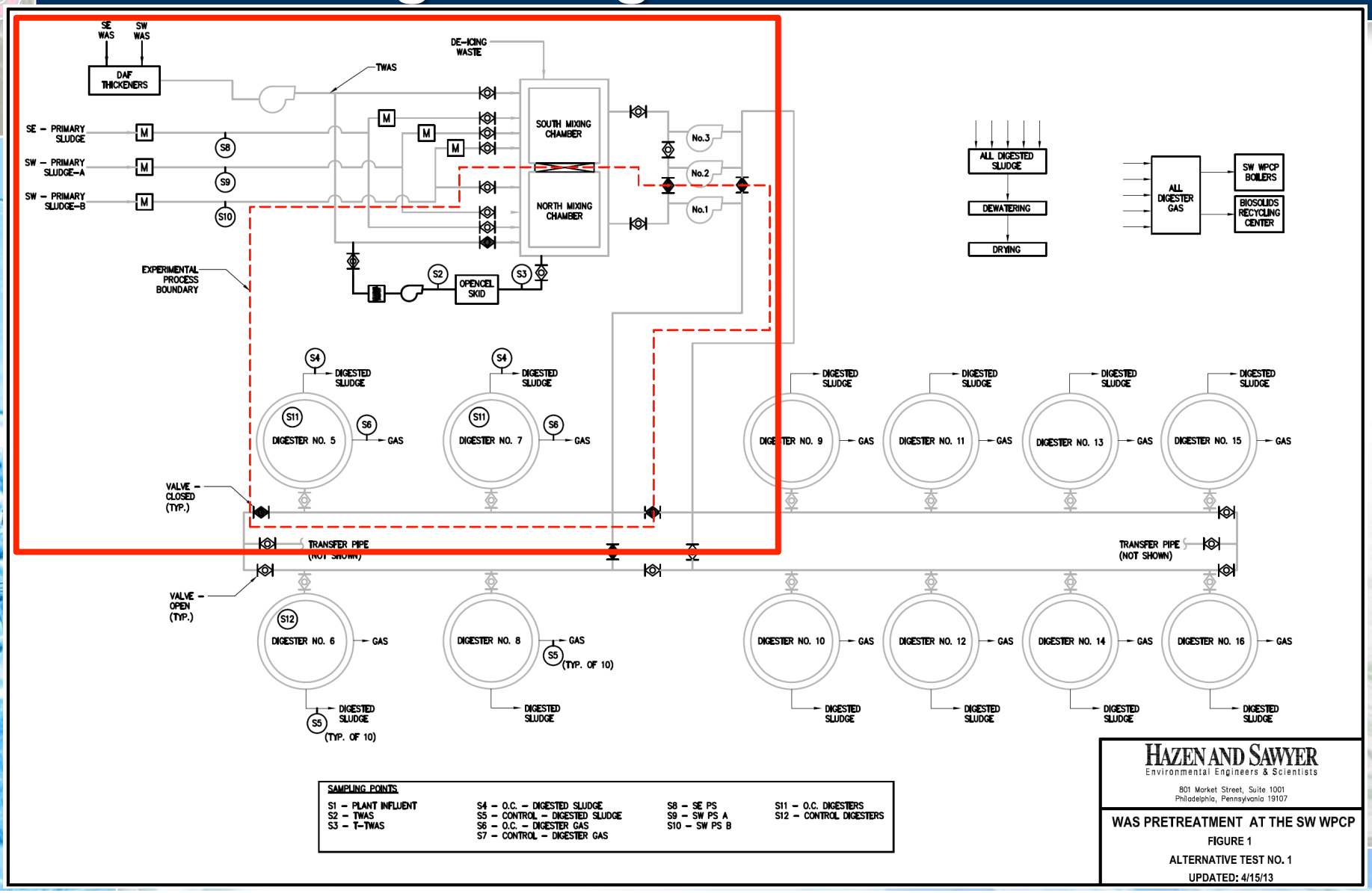
- Sludge processed from Southeast WPCP also
- Primary sludge thickened in-tank
- WAS thickened by DAF
- Blended in tanks prior to digestion
- Intermittent feed (~10 minutes) cycling through digesters at ~650 gpm
- 12 digesters
- Digested sludge sent to 3rd party dewatering/drying facility

Pilot Testing Goals

- Determine impact of OpenCel on digester gas production
- Determine impacts of OpenCel on dewaterability and polymer consumption
- Perform economic assessment of full scale implementation of OpenCel

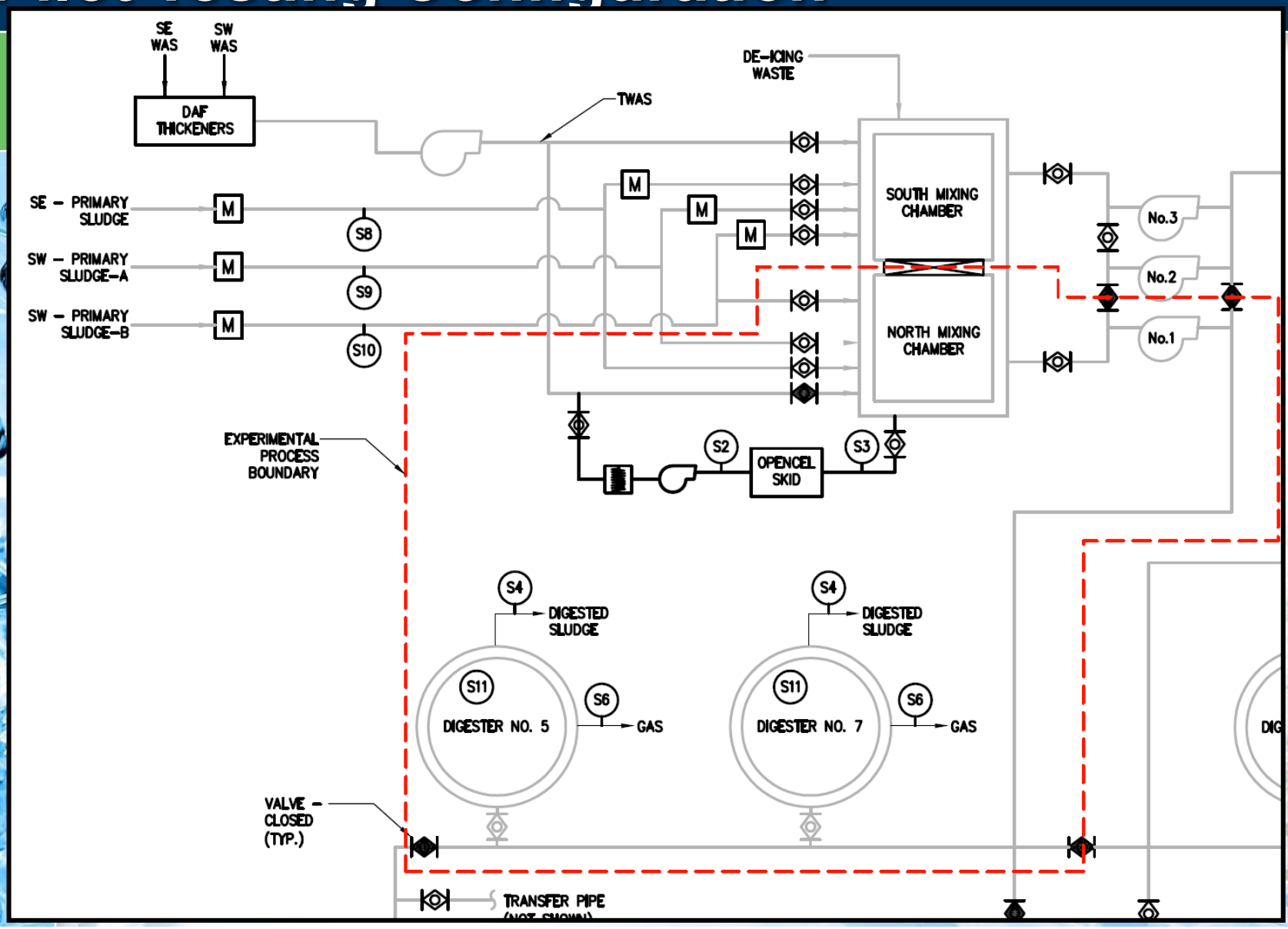


Pilot Testing Configuration



PD-Sw

Pilot Testing Configuration



PD-Sw

Pilot Testing Container

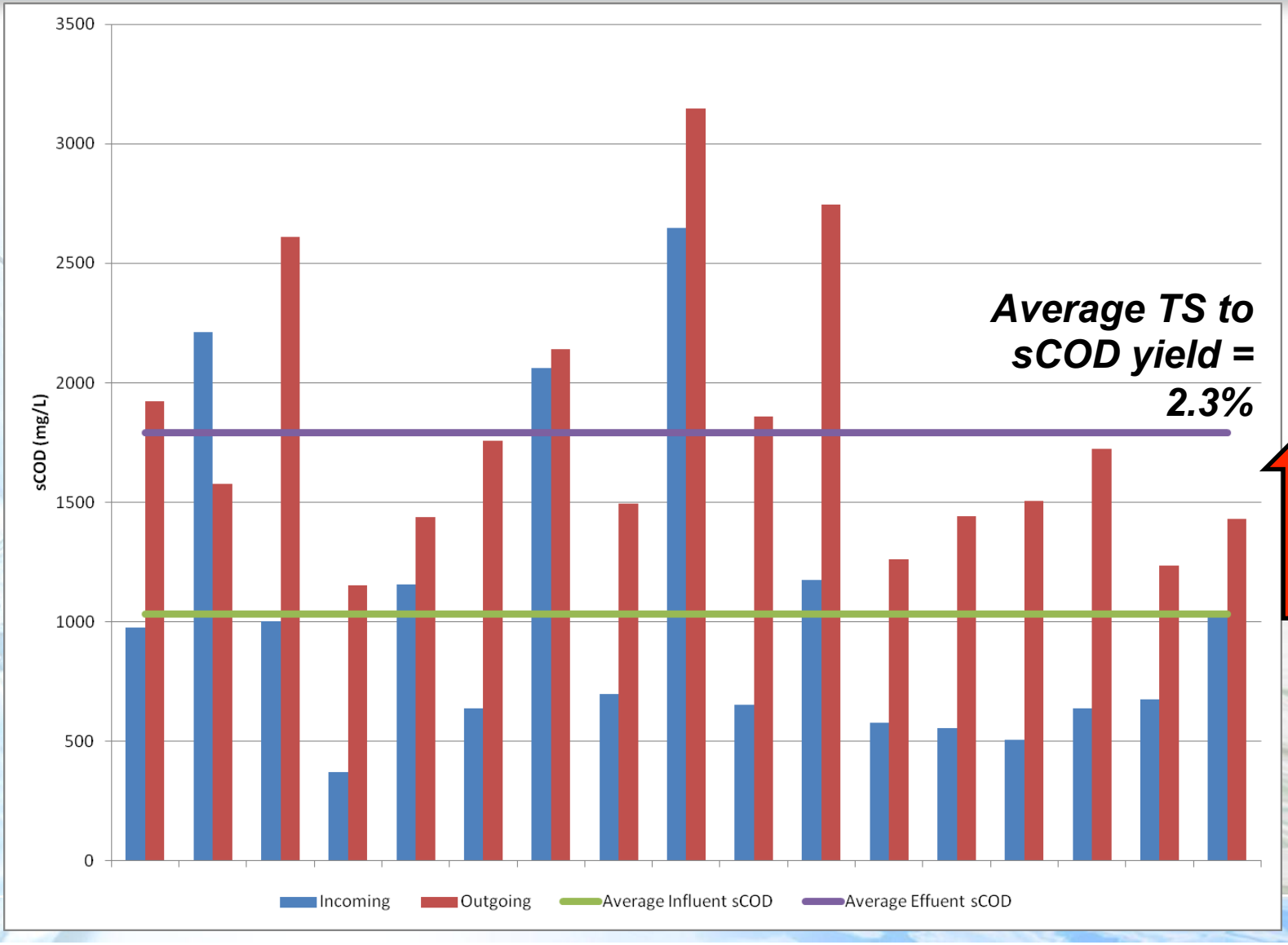
OpenCel Unit Inside Container

So Let's Get to the Performance…

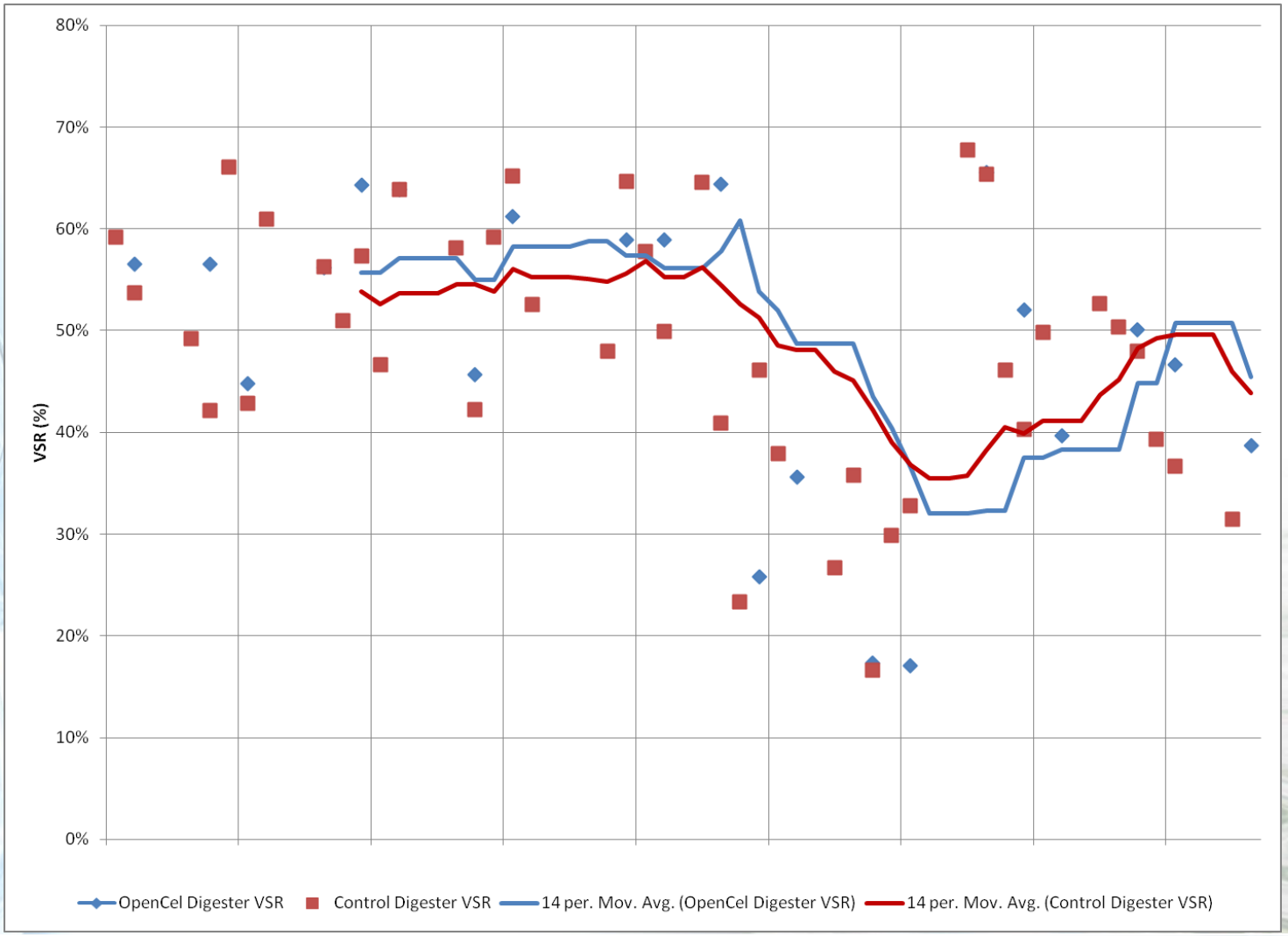
- Startup has been completed and data is beginning to be generated

- Some lessons learned:
  - Sludge conductivity is critical
  - Constant TWAS availability is critical
  - Need tie-in upstream of feed pumps to provide safety shutdown if TWAS not available

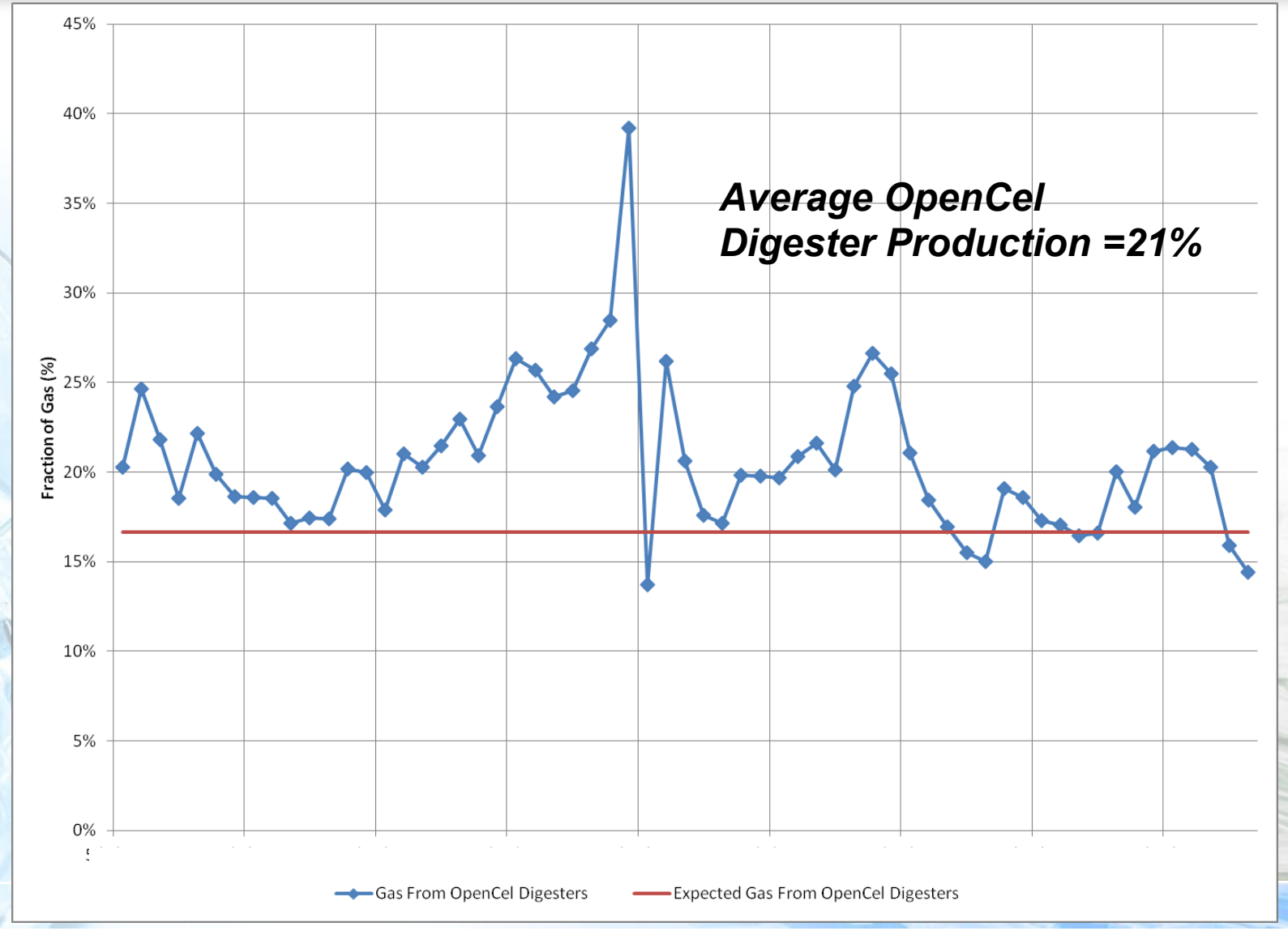
Soluble COD Results



Volatile Solids Reduction



Digester Gas Production



The Future is Bright…

- The pilot test is well configured to provide meaningful results:
  - Good control v. experimental setup
  - Extent of monitoring is excellent to provide proper data
  - Good communication between parties
  - Dedication by all involved to make this a success

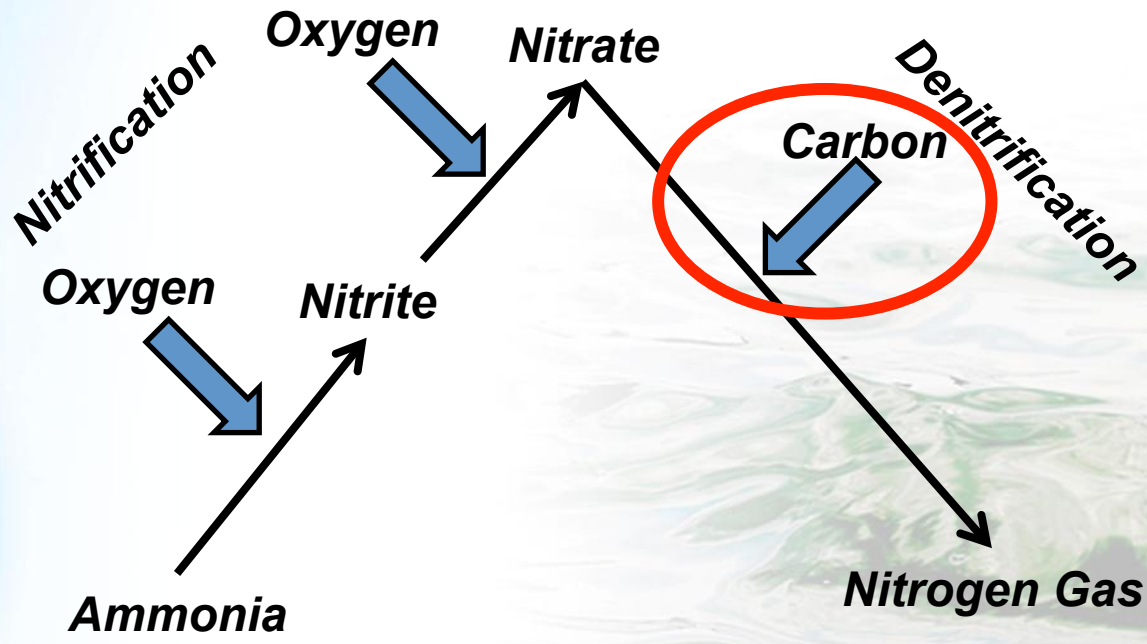
Case Study #2:
Henrico County, VA
Water Reclamation Facility

Henrico County WRF

Carbon's Role in Nitrogen Removal

- Typical nitrification-denitrification process requires external (supplemental) carbon source to complete nitrogen transformation

$$1.25CH_2O + NO_3^- + H^+ \rightarrow 0.5N_2 + 1.25CO_2 + 1.75H_2O$$

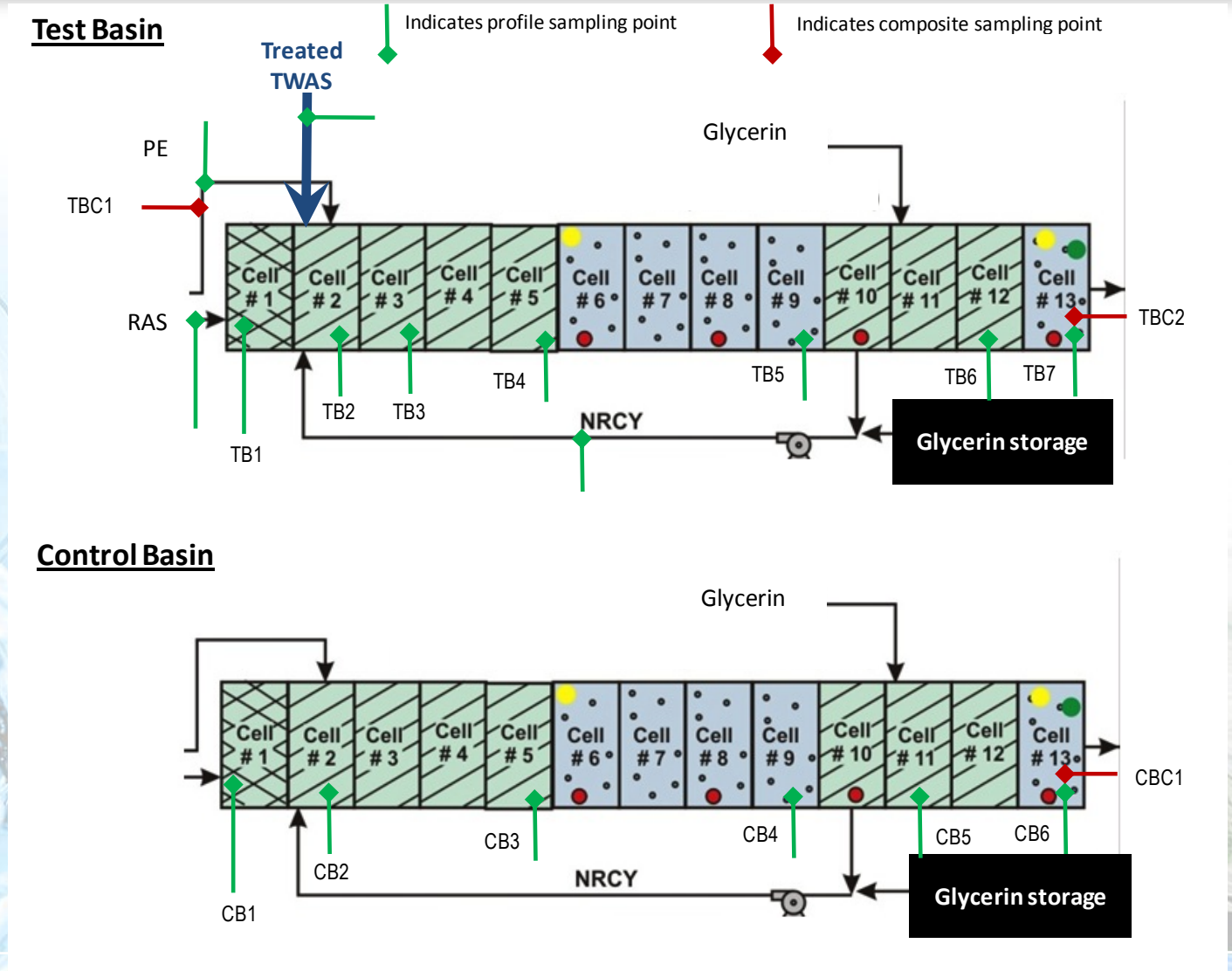


Pilot Testing Approach

- GBT-thickened WAS pretreated using OpenCel
- Lysed sludge added to initial anoxic zone to replace/ augment glycerin use

- Considerations:
  - “Dirty” carbon source
  - Additional ammonia loads
  - Careful coordination during pilot to meet strict effluent TN limits

Experimental Configuration



Implications for Pilot Testing

- Assume yield is 0.09 mg ssCOD/mg TS

OpenCel Flow (gpm)	Percent of existing first anoxic COD demand that can be replaced by OpenCel
20	39%

- Assume yield is 0.01 mg ssCOD/mg TS

OpenCel Flow (gpm)	Percent of existing first anoxic COD demand that can be replaced by OpenCel
20	4%

Conclusions

Conclusions and Observations

- Pilot testing is always critical
- Unforeseen issues are standard with pilot testing
- Bench scale and full scale operations can often vary
- Strong experimental setups are critical to determining true benefits
- Cooperation between all parties greatly improves the potential for success

Special Thanks to All Contributors

- Co-Authors
  - Ya-Chi Tsao, PWD
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  - Mark Bottin, H&S
  - Jared Alder, OpenCel
- Other project staff
  - PWD
  - OpenCel
  - Henrico County
  - HRSD
  - Hazen and Sawyer

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